With Our Community, For Our Community: Expanding Possibilities for Engaging in STEM

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We examine shifting perceptions of STEM for Latinx teens involved in a "Community STEM" environment. This design shows promise in broadening the definition of science and leveraging expertise of STEM-underrepresented youth. However, these programs are still not typical and merit further investigation. Therefore, we examined a Community STEM project where Latinx teens addressed local noise pollution. Teens documented sound levels, created graphs and maps, presented to stakeholders, and built acoustic panels. Researchers employed an ethnographic perspective, identifying science-relevant roles and artifacts. Artifacts became focal points, promoting reflection on noise pollution, potential solutions, and roles in the project and community.

Introduction

Although equity scholars have worked tirelessly to improve minoritized students' experiences with science, a great amount of work remains (Bang et al., 2012; Freeman et al., 2009). Unfortunately, with the focus on passing high stakes tests, elementary teachers tend to prioritize language arts and math (National Research Council, 2012), while afterschool programs devote more time to homework and test prep rather than science enrichment (Freeman et al., 2009). Additionally, educators both in and out of school report they lack the training and resources needed to enact high quality science instruction (National Research Council, 2012; Freeman et al., 2009). One potential response is the Community STEM model (see Nation & Hansen, 2021), which is grounded in partnership between researchers, afterschool staff, and community members and draws heavily from the work of equity scholars in science education (Fusco, 2001; Calabrese Barton et al., 2013; Birmingham & Calabrese Barton, 2013).

The community STEM model integrates science with engineering and other disciplines in ways that are meaningful to participants, contextualizing learning within community and environmental issues. Although youth participate in elements of citizen science such as real-world data collection, analysis, and dissemination, the project is conducted in partnership with community members rather than relying on them solely for mass data collection. Students authentically contribute to the design of the project, and new questions arise that move them toward more complex investigations, usually to learn about and improve their local environment. Students research their surroundings and then build their own devices or structures, requiring integrated STEM where they participate in scientific practices like carrying out investigations and engineering design practices like designing solutions. These projects show promise in broadening the definition of science and leveraging expertise of youth from STEM-underrepresented groups such as girls and students of color (Birmingham & Calabrese Barton, 2013; Calabrese Barton et al., 2013). However, due to time, funding, and training constraints, as well as limited views on what disciplinary science means, these programs are still not typical in schools or afterschool science. More research is needed to consider patterns of participation in these novel learning environments and characterize how they can support engagement.

Therefore, we examined a year-long Community STEM project at an afterschool center in an unincorporated area of Central California. Fifteen Latinx teens participated by discussing their community's noise pollution issue and recording decibel readings to document and map sound levels. A subset of the teens created graphs and maps, and presented them to community stakeholders. Then they documented sound levels in their afterschool center and created acoustic panels for their study room. Three researchers employed an ethnographic perspective and performed thematic coding on video and audio records of sessions, individual and group interviews, and student artifacts. We utilized Figured Worlds framing (Holland et al., 1998) to explore the spaces of the teens, and how these worlds outlined norms for participation and recognition in science. We asked:

- What roles did the teens take up?
- What science identity artifacts were produced, and what were their meanings?

This work documents the experiences and identity processes of a group of Latinx youth and adds to an emerging body of research on Community STEM environments. The paper has implications for research and practice, elevating the voices of Latinx youth as community scientists and change agents and documenting the dynamics of a Community STEM learning design.

Literature Review

People who identify as Latinx are the largest minority group in the U.S. (Census Bureau, 2018); however, they remain underrepresented in STEM degrees and fields (National Science Foundation, 2017). To compound the problem, there is a dearth of research documenting the experiences of Latinx students in STEM. Studies tend to focus on predicting degree attainment instead of illuminating interest in or reasons for studying STEM (Crisp & Nora, 2012). More research needs to focus on documenting the supports, obstacles, and experiences of Latinx students in STEM. In particular, despite being the most underrepresented group in STEM, "few researchers have attempted to understand how women of color perceive and experience science and mathematics" (Crisp & Nora, 2012, p. 7). The available research on Latinx women points to the importance of a personal connection or role models in science (Beeton et al., 2012; Sorge et al., 2000), and recognition by others as a science person (Carlone & Johnson, 2007). Factors such as family support and institutional advocates are crucial as well (Crisp & Nora, 2012). However, barriers to participation include lack of awareness about science careers, financial constraints, low expectations from others, and lack of relevance or views of science as "a white male profession" (Beeton et al., 2012, p. 72). By middle school, Latinx young women are "the least likely of any group to have STEM career aspirations" (Crisp & Nora, 2012, p. 7).

Critical scholars argue that to confront these barriers and shift Latinx students' perceptions of and participation in STEM, we must redefine what it means to do science or be considered good at science. Conventional school science privileges Eurocentric knowledge, meaning the ways that students from non-dominant communities think about and participate in science are often dismissed or considered inadequate (Bang & Medin, 2010; Mensah & Jackson, 2018). Instead, we need to shift power dynamics and create expansive learning experiences that leverage and legitimize diverse ways of being in science (Kang & Nation, 2021). Afterschool contexts could be a strong starting point for this shift towards equitable science, since their flexibility allows programs to incorporate diverse ways of knowing, blur disciplinary boundaries, and promote exploration in STEM and skill-building opportunities relevant to STEM careers (Afterschool Alliance, 2015; Krishnamurthi et al., 2014). Community STEM programs, incorporating authentic making and citizen science practices for social justice ends, can broaden young people's definition of science and value the cultures of underrepresented students while encouraging them to explore new science-related interests and identities (Calabrese Barton & Tan, 2010; Varelas, 2012). To better understand these complex out-of-school science environments and associated identity processes for girls and students of color, we utilize the Figured Worlds model, described below.

Theoretical Framework

The Figured Worlds model is a large-scale cultural model (Holland et al., 1998) that has been widely used in educational research (Urrieta, 2007). The figured world refers to a "socially and culturally constructed realm of interpretation" (Holland et al., 1998, p. 52), and provides a lens for understanding how people within the "world" take on dynamic roles, are recognized by others in ways that define their participation, and place value on certain outcomes (Holland et al., 1998, Urrieta, 2007). People create and maintain figured worlds with others, co-producing artifacts, activities, discourses, and performances and ultimately outlining norms for participation and recognition in that realm (Gonsalves & Seiler, 2012; Holland et al., 1998). Individuals are socially identified and offered certain positions, such as "good student", and author a response that negotiates their position (Urrieta, 2007). Certain ways of talking or doing become recognized and either repeated or rejected, leading to circulation of cultural practices (Wortham, 2006).

The figured world framework has been used extensively to understand the authoring of science identities (Urrieta, 2007; Varelas, 2012). By studying learners as participants in figured worlds, researchers can uncover the local norms of doing science, and understand how definitions of science and science people are established (Rahm & Gonsalves, 2012). Figured worlds can be "as if realms" where people create new ways of being and doing and ultimately new worlds through "the arts and rituals created on the margins of regulated space and time" (Holland et al., 1998, p. 272). Using the "as if realm" framing from figured worlds could provide insight into the new territory of Community STEM programs. The figured world as a "site of possibility" is pertinent in the context of our new program blending science, social action, and art. The figured worlds framing therefore provides insight into both how the culture of science is defined and shifts in new settings, as well as how youth take on new identities in these settings. While frameworks like culturally responsive education provide overarching framing and instructional approaches for science instruction (valuing students' experiences, home languages, and ways of knowing and speaking), they fall short of providing insight into the process of redefining the culture of science and what it means to be a science person.

Given the Figured World framework, identity is made visible through what people do and how that is interpreted, "by the resources they access and activate to do so, and by how they position themselves in relation to others and to the object of the activity while taking particular roles" (Calabrese Barton et al., 2012, p. 43). Identity processes take shape as social performances (Gonsalves & Seiler, 2012), where people engage in a process of "becoming" based on their performances and others' recognition (Carlone & Johnson, 2007; Stapleton, 2015; Urrieta, 2007). These performances or ways that people "figure" themselves in specific contexts become "roles" (Holland et al., 1998, p. 41), which can be momentary stances or longer interactional sequences that shape local ways of being (Bucholtz & Hall, 2005). Over time, momentary stances and roles shift into longer-term habits and patterns, which can cement into "itineraries of identity, or well-worn ideological routes along which socially positioned subjects may be compelled to travel" (Bucholtz et al., 2012, p. 157).

Discourse, roles, and artifacts communicate socially and culturally constructed ways of being; therefore, they are "living tools of the self" that influence how people experience the world (Holland et al., 1998). In the context of Community STEM projects, student work such as video clips, data representations, blogs, or artwork are artifacts from particular moments in time that provide snapshots of how youth are positioning themselves and authoring their identities. Researchers can use how underrepresented students talk about these "identity artifacts" to consider how they engage with science, including taking on shorter-term roles and longer-term identities not typical in a science class (Calabrese Barton et al., 2008). Identity artifacts taken from different points in time provide insight into how identities shift, yet stabilize across different social contexts and over time (Calabrese Barton et al., 2012). Following Calabrese Barton's work, we identify "signature science artifacts" (p. 81), as well as focus on the roles, resources, and associated discourses of participants. Examining and elucidating these science artifacts and surrounding discourse provides an alternative view on science competence and expertise in comparison to standardized testing or grades, and can be especially impactful for understanding nondominant ways of doing and thinking that might not be counted in traditional science classrooms.

Methodology

Project and Participants

Data were collected at the Teen Center, an afterschool site that provided bilingual programming for over 50 Latinx youth in grades 6-12. Fifteen Center youth participated in our Community STEM project from February 2017-February 2018. They surveyed residents and determined that sound pollution was a commonly reported issue, especially for Latinx families. Teens discussed the sound issue, proposed guidelines for collecting data, and recorded decibel readings across town to determine sound levels. Youth recorded during group data collection days and on their own time according to the collectively devised guidelines. Seven participants (three male, four female) analyzed data and presented their findings to community stakeholders at a Town Hall. At the Town Hall, this "data analysis team" also introduced a community maker project, inviting residents and other attendees to make acoustic panels to decrease sound levels in the Center homework room. Participants conducted pre-post-tests of sound levels and analyzed data to determine a statistically significant reduction in reverberation after installing the sound panels.

Four girls (Katie, Jatalia, Araceli, Flora) and three boys (Rafael, Tomás, and Dylan) self-selected into the data analysis team. Katie, Araceli, and Flora were in 7th grade, Jatalia was in 10th grade, and Rafael, Tomás, and Dylan were in 11th grade. Participants reported varying levels of success in school, but an overall aversion to science courses, especially ones involving math or bookwork. They all demonstrated competence and performed well in science and engineering activities at the Center, but did not view themselves as scientists or engineers and did not feel that others saw them that way either, demonstrating low "STEM identity" (Carlone & Johnson, 2007).

Table 1

Demographic Information for Each Participant

Participants	Ethnicity	Grade level	Grade in science (self report)	Identity within project
Araceli	**Latina**	**7**	**B**	**Scientist**
Dylan	Latino	11	D	Community scientist
Flora	Latina	7	B	Helpful data analyst
Jatalia	Latina	10	C	Community scientist
Katie	Latina	7	A	Designer
Rafael	Filipino	11	A	Scientist
Tomas	Latino	11	A	Scientist

Procedures

Our approach was both adaptive and emergent, starting with aligning goals of researchers and Teen Center staff, co-executing the planned steps, reflecting on the progress, and adapting to emergent circumstances in planning next activities. There was already an established relationship between the researchers, staff, and youth, and a figured world that was being continually constructed; therefore, we started the Sound Project by explicitly connecting to past activities of participants. The youth had designed and distributed surveys of community members and learned that noise was one of the most pressing issues for both college students and families. We framed the project as a continuation of this, to collect more data to examine where and when it was loud. We introduced the idea of public or community science where members of the community participate in scientific studies. After introducing the project, the researchers outlined a process of scientific investigation as 1) introduction and planning, 2) data collection, 3) data analysis, and 4) presentation to the public. After the presentation of findings from collecting sound data, the focus shifted to devising a solution in the form of acoustic panels. We followed the engineering design process of 1) identify the problem 2) explore solutions and make a model 3) build and test designs 4) improve on designs.

Project activities occurred twice a week for around two hours per session. Certain big events such as the introduction to the project, group data collection, Town Hall presentation, and installation of sound panels were more formal sessions and included all project participants (See Table 2). Other activities were more flexible with youth arriving and departing throughout the timespan and choosing if they wanted to participate and on which part. All work was conducted at the Teen Center except a few group data collection days where youth surveyed their neighborhood in teams, and individual data collection which occurred outside of Center hours and was sent to the facilitators. Data analysis sessions were more flexible since there were fewer participants, and often there were multiple activities occurring simultaneously with different facilitators and youth.

Table 2

Overall Timeline of Sound Project With Participation Type and Date per Activity

Dates	Session topic/activity	Participants
February 2017	**Introduced project**	**Whole group**
March 2017	Tested measurement app on participants' smartphones	Whole group
March 2017	Discussed initial research design	Whole group
April 2017	Collected data (in groups during afterschool sessions and individually out of this time)	Whole group + individuals
May	Analyzed data (answered research questions, made graphs)	Data analysis team
May	Built interactive map of the town with sound recordings	Data analysis team
June 2017	Presented at Town Hall to community members	Whole group
June 2017	Identified problem of noise in the study room	Data analysis team
June 2017	Test acoustic panel prototype	Data analysis team
June 2017	Decorated and shaped sound panels, designed layout	Whole group
July 2017	Installed sound panels in homework room	Whole group
Aug-Sep 2017	Post tested acoustic panel (1st trial), installed panels	Data analysis team
January 2018	Reinstalled panels, repeated pre and post test	Data analysis team
February 2018	Analyzed data from pre and post tests of room with acoustic panels	Data analysis team

Data Collection and Analysis

The research team led activities and took ethnographic notes on the design process and implementation challenges, tracing dialogic exchanges and multimodal practices across time (Green et al., 2012). In developing findings, we examined video and audio from 21 activity sessions of 1-2 hours each, and four group exit interviews. The research design was a qualitative, ethnographic case study, or "an intensive, holistic description and analysis of a single instance, phenomenon, or social unit" (Merriam, 1998, p. 27). The case was bounded by the place and the project duration, referring to the group of youth who participated in the Teen Center's year-long afterschool project to investigate, report on, and address sound levels in their homework room and broader community (Yin, 2003). We focused our analysis on the group of seven youth participants in the data analysis team. For our sub-unit of analysis within the overall case (Yin, 2003), we focus on a “key event”, or dialogue that occurred while working on a signature science artifact, to understand how participants were recognized and responded in relation to science tasks.

In Phase 1, we utilized methods from interactional ethnography (Green et al., 2012) to construct minute-by-minute event maps for each session, illustrating participant actions in a timeline (for more detail, see Nation & Duran, 2019). We then directly inscribed codes onto video to identify important components of Figured Worlds including *participant, role*, *physical tool*, *digital tool*, *artifact*, and *science practices*. We listed roles, tools, and object artifacts for each session, then performed semantic analysis (Spradley, 1980) to list all artifacts produced and forms of engagement with science throughout the project. Participants produced 33 object artifacts, including soundwave data displays, geotagged sound clips, vlogs, guideline lists, data spreadsheets, graphs, maps of the homework room or whole town, individual acoustic squares, and group acoustic panels. In exit interviews, participants listed 14 artifacts (Table 4) as particularly impactful, commenting about memorable or enjoyable activities. We next determined “signature science artifacts” (Calabrese Barton et al., 2012, p. 81) for each participant based on their comments and others’ comments in the exit interview, and the amount of time and engagement level while participating in each activity from their event maps.

In Phase 2, *positioning events* were identified based on participants’ evaluative and affective responses which communicated their “stances” (Bucholtz & Hall, 2005). These events were momentary interactions which occurred as part of normal participation within the project activities. We identified an event whenever a participant verbally responded to another participant or facilitator when interacting with a project artifact. These events were directly inscribed onto the video with timing noted. We examined the intersection of the signature science artifacts and positioning events by creating a code relations matrix in MAXQDA, which revealed the co-occurrence of codes. When an overlap was identified, this was considered a *key event*, and we transcribed dialogue to produce retrieved segments of coded video with transcripts for all dialogue about the signature science artifacts. These key events were added to participants’ event map timelines. We then coded whether the participant accepted, rejected, or negotiated the position offered to them during this key event, and if this constrained, supported, or expanded their perspectives on science. After examining events and responses for each participant in chronological order, we documented patterns of how they shifted in the way they perceived themselves or others perceived them. Additionally, to triangulate findings on perceptions of self in relation to STEM, two researchers performed emergent thematic coding of the interview transcripts to identify project roles and associated actions.

Results

Our analysis revealed that the project shaped participants’ interpretation of what constituted “Community STEM” and what it meant to be considered science people. Artifacts used to examine sound levels, report findings, and enact change were important to mediating this transformation. The roles of *scientist/science person, community scientist, maker, organizer, engineer, leader, presenter, data team member*, and *general member/helper* were discussed in interviews and triangulated in video coding (see Table 3). Roles were associated with distinct practices and tasks often linked to creating or improving different artifacts. In the next section, we present in broad strokes the social types or roles of *community scientist, scientist, maker, engineer, data team member,* and *presenter*. We illustrate what it meant for participants to affiliate (or not) with these subgroups and the associated practices. Then, we describe in depth the significant science artifact for two participants, considering these artifacts and associated discourses to be “living tools of the self” (Holland et al., 1998, p. 28). Examining these artifacts and participants’ responses over time provided insight into identity processes and shifting perspectives on science.

Roles

Most participants distanced themselves from the conventional roles of scientist, science person, or engineer; however, they were more likely to relate to roles such as maker, community scientist, or helper (See Table 3). Terms like “scientist” and “engineer” were associated more with school and jobs. Therefore, the role of scientist or engineer was constrained by how well participants were doing in these subjects at school or their enjoyment of science class tasks such as note-taking or memorizing key terms. In contrast, youth found diverse ways to characterize a maker, including sub-roles such as designer or helper. Data team member and presenter were sub-roles associated with community scientist. These roles were associated with specific data analysis and communication practices required to carry out and share results from the investigation. Community science and making were mentioned as ways to contribute to something important and make a difference, whether building panels to reduce noise or raise awareness of sound pollution on a neighborhood level.

Table 3

RQ1: Participant Identification with Specific Project Roles

	Maker	Engineer	Science Person	Community Scientist	Data Team Member	Presenter	Leader	Helper	Organizer
Araceli	√	√	√	√	√		√		
Flora	√				√			√	
Jatalia				√	√	√		√	
Katie	√	√	√	√		√			√
Dylan	√			√	√	√		√	√
Tomás				√	√	√		√	√

Interestingly, being a “community scientist” was considered separate from being a “science person” or “scientist.” Although almost everyone felt they were a community scientist, only Araceli and Katie felt like science people. In comparison to other roles, being a science person was associated more with school and specific knowledge or tasks. According to our participants, scientists knew how to code, do experiments, read, think and write. Most of our participants did not feel very confident in or enjoy their science classes at school. Only Katie and Araceli felt like science people, because they were able to code, build, and experiment. Tomás did not comment much on this, but Dylan mentioned feeling competent at science content even though he was not a science person and had failed his science and statistics classes. Flora and Jatalia were very adamant about not liking science and not considering themselves as science people.

In contrast, everyone except Flora felt like community scientists. Katie defined community science as “doing a project that could help, or make something better in your community. And in general just being a scientist, but, doing projects, experimenting and stuff.” Dylan also mentioned the scientific process yet focused on community needs with his definition. He reported that a “community researcher is a person who collects data, analyzes it, and makes a conclusion. And community because we did it with our community for the community.” Although most of our participants did not personally feel like science people or scientists, they recognized that they engaged in scientific practices with the goal of improving their community, and therefore were able to embrace the role of community scientist or researcher. The exception was Flora, who equated community scientists with public servants, felt that she had not done enough to earn this title. When asked if she considered herself a community scientist she responded, “Not really, I don’t think I made a big difference. I don’t know who I would consider a community scientist. Maybe like police or something? Like help control fires or something?” However, she answered that a community scientist “means they do research of how to help the community in different ways” and agreed when the researcher asked if she had helped the community during the project. She also stated, “I feel we did a really good job on it. I think we really succeeded on it…Because it actually did help.” Similarly, Tomás reported that participating in this project, “made us feel like we actually did something.” Dylan added that he felt “a sense of awareness in the end. Because for people who don’t know what it’s like to live in [our town] and sometimes like what these problems are. It sets up a visual of the problem and some people can see it.” Community science was a way to actively participate in addressing a local issue, by collecting data and raising awareness of the issue.

The broad goal of collectively addressing a community problem, which did not have a set outcome, enabled each member to carve out a space in the project and participate in unique ways. Despite taking ownership over different parts, everyone participated in some type of making and some type of data analysis, and either identified as community scientists or expressed similar motivations of addressing the noise issue. Araceli, Katie, and Flora described how they were makers, which was associated with the amount of time they spent on decorating and installing the panels. In comparison, Tomás, Dylan, and Rafael sometimes left decorating activities to focus on data collection or analysis and overall spent much less time on making. Sometimes the boys felt uncomfortable if the focus was on “decorating” rather than building and testing models or analyzing data. From the beginning they took up the label of data analysts, but as the project shifted into making and engineering design they were unsure how this related to their roles as analysts. They worried that the maker activities were too juvenile for them as upperclassmen in high school, felt uncomfortable when mostly girls were doing the activity, and believed that making extended beyond their prescribed role as data analysts.

Although everyone except Katie considered themselves part of the data team, the boys were more likely to refer to themselves as data team members. From the beginning of the project, the boys referred to themselves as the “data group” or “analysts”, and usually responded positively to facilitators labeling them as “data team members.” On the other hand, the girls were more likely to reject labels of “analyst” or “scientist”, and took a few months to feel a part of the data team and develop ownership over project artifacts. Flora and Jatalia initially told friends they were “just helping” the facilitators, and Katie, in particular, distanced herself from the label of data collector/analyst or part of the data analysis team. Although Katie started with the core group, after the first few sessions she decided she did not want to collect or analyze data and instead focused on other parts of the project such as documenting other people’s work and creating the acoustic panels. Katie reported that, “I never actually did the data thing because I didn’t want to…Because it’s boring. And because I don’t want to walk around everywhere…But I did like three.” Even though she collected a similar amount of data points when compared to other participants, she minimized her contribution as well as expressed distaste for the role.

She also did not feel like part of the data analysis team, and chose not to help create the graphs or map. Despite this, she mentioned learning similar things about using the app and measuring sound levels as well as "how to calculate and gather information from [our data.]."

Katie, Flora, Jatalia, and Dylan had all failed STEM tests recently or had teachers express doubt in their science or math abilities. In response, Katie and Jatalia avoided math-related Sound Project activities, while Flora and Dylan countered facilitators' statements about their science skills by bringing up school failures or other perceived inadequacies. Participants dismissed being characterized as "real scientists"; however, they recognized they were performing science and math practices relevant to what they had covered at school, and acknowledged that the facilitators took them seriously in their roles as scientists. Even though only Katie and Araceli considered themselves science people and engineers, by the end of the project participants were more open to considering these possibilities in the future. For Dylan and Jatalia, this shift was due to realizing that science could be "for the community" instead of research conducted on their communities. For Flora and Katie, they discovered new ways of doing STEM, in particular about the engineering design process and what designers and engineers do. For example, Flora, Araceli, and Katie expressed interest in learning more about engineering after the project and even applied later that year to a high school engineering academy. Katie felt pride in being recognized as "the designer" of the overall pattern for the acoustic panels, and felt engineering was a possibility since she enjoyed problem solving and art. Flora was initially motivated by helping the graduate facilitators in any capacity; however, this shifted to helping her community in general as she worked through the data and better understood the project and its goals.

Artifacts

For each participant we determined a significant science artifact (see Table 4) which mediated the thoughts, feelings, and actions of themselves and others. Araceli's significant artifact was the collection of sound clips she recorded on her phone which allowed her to document the noise problem. For Jatalia, it was the interactive sound map she created for families, which displayed sound effects around town. Katie was motivated by the wall acoustic panel with everyone's individual contributions of acoustic squares yet her overall design. Even though Flora also felt strongly about the acoustic panels, her significant artifact was the sound wave print outs because they allowed her to determine that the acoustic panels were successful in dampening the noise in the homework room, making their work valuable.

Tomás' artifact was a graph of sound levels according to the day of the week and time of day. For Dylan, the graphs were also important. However, he felt more strongly about presenting the PowerPoint slide with overview information because it helped him conceptualize the project and the meaning of their findings. For Rafael, it was the slide with the top three loudest and quietest sounds which represented that the town could be loud but also a peaceful place. The boys' significant artifacts were all data displays, produced from data analysis tasks. In comparison, the girls had a greater diversity of significant artifacts ranging from sound files to acoustic panels. The girls were also more likely to have positioning event responses coded as constraining or expansive rather than supportive, potentially indicating greater shifts in their views of themselves in relation to science. This slower process, with more moments not directly supporting their ideas of science, provided the rationale to highlight the artifacts and associated identities of the girls.

Table 4

RQ2: Signature Science Artifacts according to Participant

Participant	Signature Artifact	Participant Reflection	Artifact Mediation
Araceli	**Sound clips recorded on phone app, geotagged and with decibel information**	**“We just go around [our town] and just like use the app and also like…we just recorded with an app. Yah and see and collect all the data to see how much loud or quiet it is.”**	**Sound clips served as documentation of the noise problem, which Araceli related to personal experiences with loud music and neighbors. Collecting the sound clips was an opportunity to explore the neighborhood and connect with friends.**
Flora	Print outs of amplitude over time in pre and post conditions, used to estimate reverberation time	“I learned how it worked and how it made a big difference in the room…like how it absorbed sound.”	Sound print outs mediated participation in a group analysis activity and invited Flora’s individual perspective which was valued by the group; the resulting data from the print outs were viewed as useful to the Teen Center.
Jatalia	Map of town with linked audio, to click on nine areas and hear representative sounds	“It was fun to hear all the data and point the map out and everything…It kinda impacted me because I didn't really realize how [our town] could be peaceful. I didn't know there's streets or like this side of [our town] is quieter than this side.”	Analysis of the data and construction of the map mediated Jatalia’s generation of insight on the patterns of noise in the community, which were seen as a valuable information source for community members.
Katie	Individual decorated acoustic squares installed on plywood and mounted to wall to form large panel	“I'm not sure what the difference is with the acoustic panels. I mean, to me it seems the same they're like decoration on the wall. I guess it could work, if it is I'm not noticing it. The panels worked out good because like people did it.”	The design for the overall layout for the panels presented a challenge for Katie to construct and assess for effectiveness. Investment in the construction was based mostly on aesthetic value rather than solving the noise issue, and yielded surprise and satisfaction upon successful outcome.
Dylan	PowerPoint slide with information about the project in general and overview of data analysis	“The presentation, yeah it was pretty cool. Overall because it had all of what we did together, and when the presentation was going on, I kind of remembered every single thing we were doing. So that was definitely the part I most remember because it reminded me of everything.”	The descriptions and analysis of the sound issue as presented on the presentation slides were viewed by Dylan as a resource for the community; construction of the slides was seen as a collective achievement.
Rafael	PowerPoint slide with top three loudest and quietest sounds and description	“There's like different locations that we have recorded and that there's also traffic and parties and the decibels range from 27 to 108. We wanted the loudest sounds but we also wanted to record the quietest sounds to show that [the town] could be a quiet place, a peaceful place.”	The formatting of findings as presented were place-based insights about the quality of sound in the community and allowed for reasoning about the source of sounds, and viewing Rafael’s town in new, positive ways.
Tomás	Graphs of sound levels according to the day of the week and time of day	“We definitely made like graphs and information for other people to use, and like maybe other people can use in studies and stuff like that.”	Graph construction on detailed sound information was seen by Tomás as a useful scientific resource and a step to future study.

Signature science artifacts. While we analyzed artifacts and positioning events for all youth on the data team, we focus on Jatalia and Flora to provide more in-depth examples of positioning events as evidence of the role of the artifact and surrounding discourse in shaping their participation. We discuss associated identity processes over time, including the girls’ view of themselves in relation to STEM.

Jatalia the community scientist. For Jatalia, the project and her signature artifact of the map (Figure 1) offered an opportunity to develop new identities. Working on the map and linking the sound effects gave Jatalia an excuse to come to the center regularly, and made her feel important to the project. In her exit interview she stated that her role changed over time because at first she was peripheral to the project but by the end she was expected to come as part of the data analysis team. She explained that other group members would text her saying, “Jatalia, you should come to this science thing because [the facilitator] wants you to come” and that made her feel included and motivated her to come regularly. She felt “recruited” into the figured world of community science at the Center, and she began to take ownership over the map as she personalized it.

Figure 1

Map of Town With Linked Sound Effects Collected by Participants

Visual of a map with linked sound effects

Preparing her presentation notes for a Town Hall provided the opportunity to reflect on why the project and the map were important to her. When asked for her reasoning for the map, the facilitator helped Jatalia articulate why this was important to her:

> Facilitator: Like, okay, yah displaying the data, talking about the research, actual sound levels. But, like, what is the purpose of it? Why would that matter? Would it happen?
>
> Jatalia: Why…? Because it's, just by

> looking at it you can see like you don't have to like zoom in to see. ((Pointing around map, gets closer to it, squinting))
>
> Facilitator: Okay, how would this help someone who was moving to [the town]? Like let's say I'm a family and I want to move here with my family.
>
> Jatalia: Don't. I'm just kidding. ((Laughs)) It's like to move closest to like the quiet area.
>
> Facilitator: Exactly.
>
> Jatalia: ((Writes on paper. Puts pencil down, claps then drums table triumphantly))

In the Town Hall presentation, she expanded on this idea of the groups' work benefiting families. She stated:

> What we hope to happen in the future, our next steps are we want to go out and get more data points…We want to display data as maps of [town] sound levels, physical or digital. We hope in the future to show on a map where there was the loudest noise and the quietest noise. For example if you are like a family, one who moved to [town], and you want to see where it's quietest and we are hoping later in the future we can have maybe like a red color where it's like the loudest and like quietest would be like blue.

She explained in the exit interview that she felt the map was unfinished and she planned to continue collecting data to make the map more accurate and in particular to highlight loud, party areas for the local Latinx families to avoid. She said, "I feel like the goal of the project was just to spread awareness about the sounds of [the town]…it's not always loud it has its moments when it's quiet and it's peaceful it's like [the town] is not a bad place." She wanted to make sure their data was useful, as an accurate depiction of the noise problem and as a resource for Latinx families to find ideal areas to live.

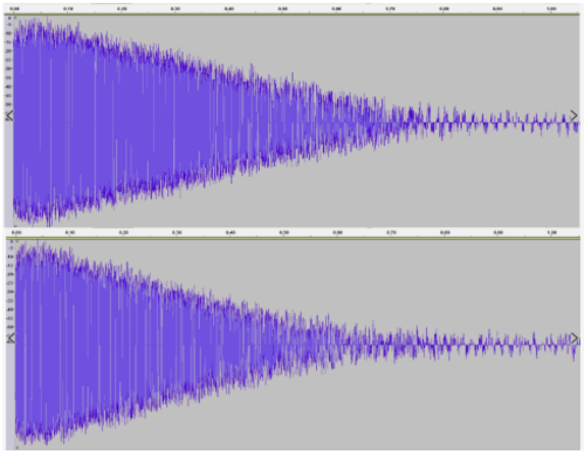
She also recognized the importance of community members collecting, analyzing, and disseminating this information. She explained that, "A lot of people come in and do science" but it was uncommon for it to be done by Latinx community members like her. She felt that Latinx families rarely benefited from scientific investigations by outsiders because the research questions were not relevant to the immediate community, or because the findings were not disseminated. Community members as researchers offered a way to change power dynamics for Latinx residents who were a minority group living in a "college party town" composed primarily of university students. As both community members and researchers, the data team could ask questions about their concerns such as noise pollution, and share their knowledge of quiet and loud areas to benefit local Latinx residents. Although Jatalia recognized the value of the team practicing community science, it took until the end of the project for her to articulate an identity as a community scientist. In the exit interview, the facilitator asked if she thought of herself as a community scientist after she defined the term. She replied, "Now that I realize, yah."

However, this new identity as a "community scientist" did not influence her view of herself as a science person. When asked if she was a science person, she answered, "At the moment, not really", and that "they think that I don't like science at school." She felt that science at school was "just really boring" and that the community science done at the Center was "different in a good way" and "if only science was so easy like this in school I think I would pass any day." Although she used tools like excel and PowerPoint, collected data and conducted experiments, and presented her findings, applying similar scientific knowledge and practices to school science, her view of herself as a science person did not change as it was connected to school and not the project. While the narrative of "bad student" in science persisted, she was able to take on a new identity as "community scientist." She felt valued in the project for her contribution, and proud of her potential to help local families in the future.

Flora the helpful data analyst. Similar to the map for Jatalia, the sound wave printouts offered Flora the chance to engage with science in a new way that she found empowering and relevant to her community (See Figure 2). She realized that she could combine science with service through testing the sound panels, and at the end commented that, "I feel proud that I helped, that I helped in this project because it was very useful." Her favorite part of the project was "the sound panels because I learned how it worked and how it made a big difference in the room…like how it absorbed the sound."

Figure 2

Pre (Top) and Post (Bottom) Sound Wave Printouts That Show Amplitude Over Time, or Reverberation Time



Picture of soundwave printouts

Flora felt helpful because she worked on a successful project, but also because she was positioned as a data team member and performed as a conventional scientist. She was given a position of relative power on the data analysis team. Initially the facilitators taught Flora how to estimate the slope and x intercept of the sound waves to determine the reverberation time, or the number of seconds until the test sound was inaudible in the homework room. After providing feedback on the first one, Flora and the two facilitators each performed analysis independently but side-by-side, with the co-facilitator saying, “Alright, let’s do a couple right now…I’ll do this one.” Beyond working at the same pace as the adults on the analysis, her ideas and concerns were taken seriously. When calculating the pre-test mean, she pointed out an intercept data point that was much larger than the others and together Flora and the co-facilitator verified it was an error. In another instance, Flora was positioned as an authority figure as she provided advice and helped the lead facilitator analyze an anomalous data point. In other cases she was engaged in real-time problem solving with adults, including participating in complicated discussions with science vocabulary including “maximum amplitude” and “exponential decay”. She also contributed authentically in confirming that the panels were successful. She determined that it was a success due to the differences in the pre and post means, and announced, “it did work” to which the co-facilitator responded, “we proved it, it was a success.”

Despite feeling empowered through the data analysis, Flora regularly commented that she was bad at science and rejected the position of “scientist” or “community scientist” offered by the facilitators. She commented that she disliked her science class and teacher, felt it was useless, and made comments such as that she was “probably going to fail this week’s test.” She had accepted the narrative that she was bad a science and not a good student in science class, even though she recognized she had applied what she learned that year in school about how to conduct an experiment and use excel to calculate averages. Her distaste for school science transferred to the science activities at the Center, and at the beginning she expressed surprise that the community science work was still science since it felt different than what she had done before. After initially reviewing the pre-post data for the sound panels she exclaimed, “Sciiiiiience! This is science!” to which the facilitator said, “This is science. You’re a citizen or community scientist.” However, Flora replied, “Uhhh. Not the best one.” Flora saw how science could be relevant and authored a science self which connected science practices with her valued identity of helper. By assisting the data team, and by proving that the overall project was useful, she was helpful on multiple levels and felt successful. However, while she realized connections between science class content and the project, and felt competent as a data analyst and a helper, she still did not see herself as a “scientist” or “science person.”

The figured world of Community STEM functioned as a new world of science possibilities for our participants, centered on playful, artistic, personalized activities that differed from the science they experienced in school. The program supported students developing expanded views of STEM, positioned them as co-learners with adults, and provided ample choices for activities and roles. Participants were able to find personally meaningful reasons to participate and explore deeply given their interests in specific artifacts.

Artifacts played a significant role in presenting possibilities and constructing identities. Araceli used sound clips to relate to different aspects of the project, and develop confidence in her skills as a scientist while documenting the noise problem. Jatalia’s sound map displayed the data but was also a potential resource for families like hers. The acoustic panel for Katie both united individuals’ contributions and positioned her as the overall designer. Flora’s analysis of the sound wave print outs demonstrated the success of the acoustic panels and proved to her and others the value of her contributions. Rafael, similar to Jatalia, felt empowered as a community scientist. He found meaning in creating a list of sounds for the map, and reported at the Town Hall on areas that were relatively quiet and peaceful and argued against oversimplifying the town and its problems for families. Tomás and Dylan felt proud of their graphs and presentation slides because they depicted their findings as data analysts. They also recognized their role in overseeing and synthesizing findings from the collective effort of their peers in the project. Overall, the artifacts required longer-term participation with peers and facilitators, becoming focal points and promoting reflection on the noise problem, potential solutions, and their role in the project and larger community.

Discussion

While many challenges remain for science educators, the community STEM model appears promising for supporting afterschool educators in providing more complex science tasks which build science-relevant skills and identities. According to their exit interview reflections, our participants developed dispositions other researchers have documented in relation to making or community science projects such as resilience and creativity (Sheridan et al., 2014) and decision-making and "optimism coupled with realism" (Schusler & Krasny, 2008, p. 274). Additionally, the long-term nature of our Community STEM project, coupled with the complexity of an authentic scientific investigation, encouraged participants to develop unique roles and expertise within the project. Similar to Ballard and colleagues' (2017) findings, our project promoted diverse roles and practices in order to accomplish the data collection, analysis, and communication. Participating in the data analysis and presentation were compelling to participants as they viewed themselves as authentic contributors. Additionally, the flexibility of the project allowed for new roles that might have initially seemed unrelated to science. Expanded forms of participation are especially relevant to Community STEM programs, as these are "as if" worlds of imagination, play, and discovery at the margins of preexisting figured worlds of science (Holland et al., 1998; Kane, 2012).

In order to achieve these new "as if" worlds, program designers and educators need to be thoughtful about the design of projects. Grounded in the literature and findings from this project, we propose that projects need to be long-term with authentic scientific and engineering tasks, allow for multiple entry points, and arise from an equitable power structure with community partners (Nation & Hansen, 2021). Previous research on youth-oriented citizen science indicates that students thrive in projects where they contribute to real data analysis and dissemination (Heggen et al., 2012; Purcell et al., 2012; Ballard et al., 2017; Roche et al., 2020). Our findings aligned with this, as participants had the strongest association with roles like "data analyst" and "community scientist." Additionally, the authentic context created unique roles that needed to be filled to achieve the collective goal, which meant participants felt needed. Setting goals of presenting at a Town Hall or revealing the acoustic panels provided an authentic audience and a clear timeline. Projects focused on addressing an authentic problem in partnership with community members can help students to take on unique roles and develop expertise linked to both science and community activism. An equitable research-practice partnership meant elevating the rich knowledge that practitioners, youth, and community members bring. Youth responded differently when they knew our activities and project direction shifted based on their input and comments like Jatalia's revealed the importance of feeling essential to the project. Additionally, they were able to see how science could take different shapes from what they saw in the classroom, as the project work was interdisciplinary, collaborative, artistic, and community-oriented.

Our project opened the range of expression for science identity to include many diverse roles, but while constructing new identities as "community science experts" (Calabrese Barton et al., 2013), most of our participants did not see themselves as "real scientists" or "science people." This potentially contradicts findings from other Community STEM or citizen science programs that encouraged more students to pursue science by breaking down stereotypes about what it meant to be a scientist (Trautmann et al., 2013). It is worth further consideration how to bridge science in school as a type of subject matter to the real-life application of science. Given that Latinx students tend to have lower self-efficacy and view themselves as less competent in school science and math compared to White students (Crisp & Nora, 2012), how can afterschool contexts construct counternarratives that are meaningful within school and beyond? Although programs can open up the range of possibilities to practice science, it is worth exploring the meaning of these identities if they do not transfer to other contexts, and if students continue to feel excluded from the figured world of school science.

Still, participants constructed intersecting identities as Latinx youth, scientists, and community members that seemed richer than traditional school science as defined by being good at certain tasks like memorizing or taking notes. Artifacts were helpful in highlighting the "multiple sites of self" (Holland et al., 1998, p. 28) and the intersection of identity and power. Jatalia and Dylan were motivated by helping local Latinx families, who were sometimes not privy to the research dissemination or related decision making by university or researcher investigations, as low-income immigrant residents and non-college students. They recognized the relevance of their intersecting identities as local residents and Latinx youth while constructing new identities as community scientists and activists. All of the youth had stories about the noise issues and the power dynamics of loud college students and children trying to study or parents needing to get up early for work. Their intersecting identities, including minority status, motivated many individuals from the data analysis team to participate in project activities and produce community science artifacts.

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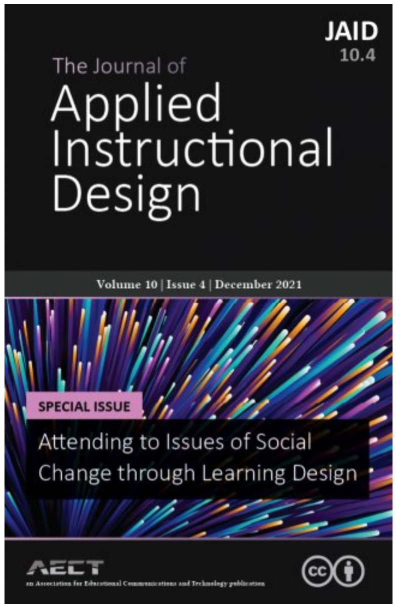

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